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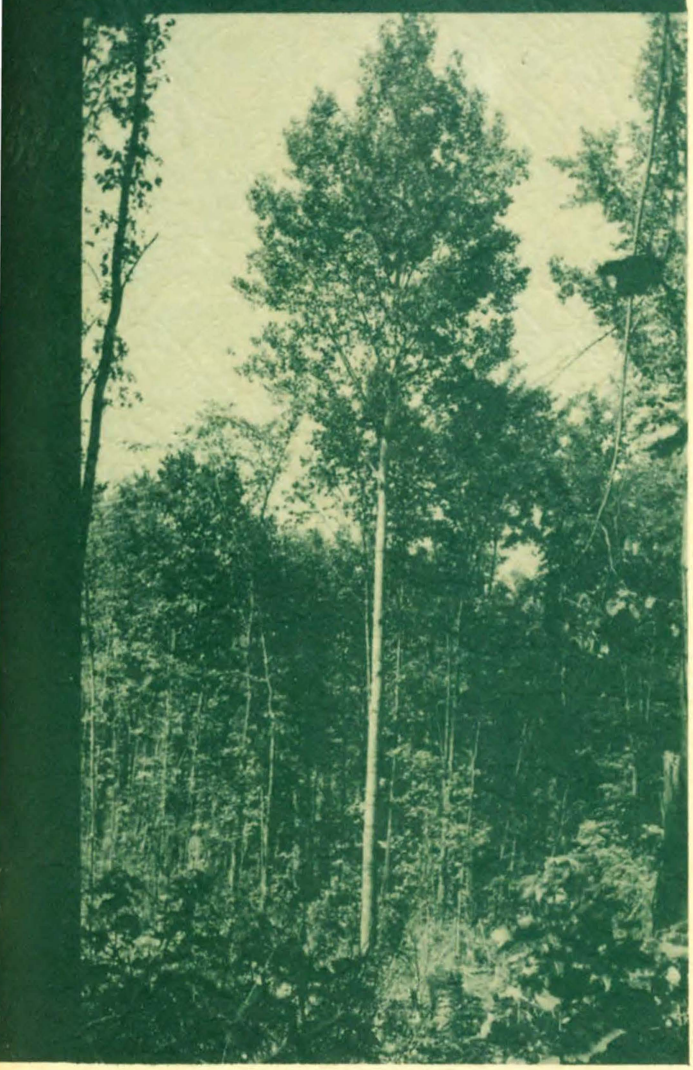
SILVICAL *Characteristics* OF...

BIGTOOTH ASPEN

(*Populus grandidentata*)

Paul E. Slabaugh



LAKE STATES FOREST EXPERIMENT STATION

M. B. Dickerman, Director

FOREST SERVICE

U.S. DEPARTMENT OF AGRICULTURE

THE SILVICAL REPORTS

During 1907 and the following several years the U. S. Forest Service issued a series of silvical leaflets which covered the broad characteristics of a considerable number of major timber species. Since then much new knowledge has accumulated--some of it published in a variety of sources. There is also a considerable store of unpublished silvical information in the files of the forest experiment stations, the forest schools, and some other agencies. To compile this information systematically and make it available to foresters generally, the Lake States Forest Experiment Station is preparing reports on 15 individual species. Similar reports are being prepared by the other Federal forest experiment stations. When completed, these individual species reports will provide the basis for a comprehensive manual of silvics for the important trees of the United States, to be published by the U. S. Forest Service.

This report is one of the series being prepared by the Lake States Station. A preliminary draft was reviewed by several members of our own Station staff and by a number of well qualified staff members of other forest experiment stations, colleges, and universities; Federal, State, and Provincial forestry organizations; and forest industry. Their comments helped the author to make this report more complete, more accurate, and more up to date.

Every effort has been made to ensure the accuracy and completeness of the information concerning the silvical characteristics of each species consistent with a brief treatment of the subject. We shall appreciate it, however, if any errors or omissions of important information are brought to our attention.

M. B. Dickerman

M. B. Dickerman, Director

Cover: A typical bigtooth aspen in Michigan (photo courtesy Forestry Division, Mich. Conserv. Dept.). Drawing represents leaves and fruit.

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SILVICAL CHARACTERISTICS OF BIGTOOTH ASPEN

(Populus grandidentata Michx.)

by

Paul E. Slabaugh
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Bigtooth aspen (Populus grandidentata Michx.) derives its name from the large irregular teeth of the leaf margins. More frequently it is referred to as aspen or "popple" when found growing with the more common quaking aspen (P. tremuloides Michx.) or by itself. Other common names are largetooth aspen and poplar.

DISTRIBUTION

Bigtooth aspen is essentially a tree of the north central and northeastern United States and southeastern Canada (fig. 1). Its botanical range extends from Nova Scotia west to southeastern Manitoba, and from Maryland west to Iowa. It also extends to the south locally in western Tennessee and in the mountains of western Virginia and western North Carolina (26).[2/] In eastern Canada it is found principally along the St. Lawrence Valley; elsewhere it is scarce, comprising with quaking aspen less than 10 percent of the total stand in areas undisturbed by man (18). It occurs in greatest abundance in the Lake States.

The commercial range[3/] is less extensive; it is confined roughly to the northern half of the botanical range (fig. 1).

1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minn., in cooperation with the University of Minnesota.

2/ Names and dates in parentheses refer to literature cited on page 15.

3/ The commercial range is defined as that portion of the botanical range in which the species grows to commercial size and is an important species in the forest type.

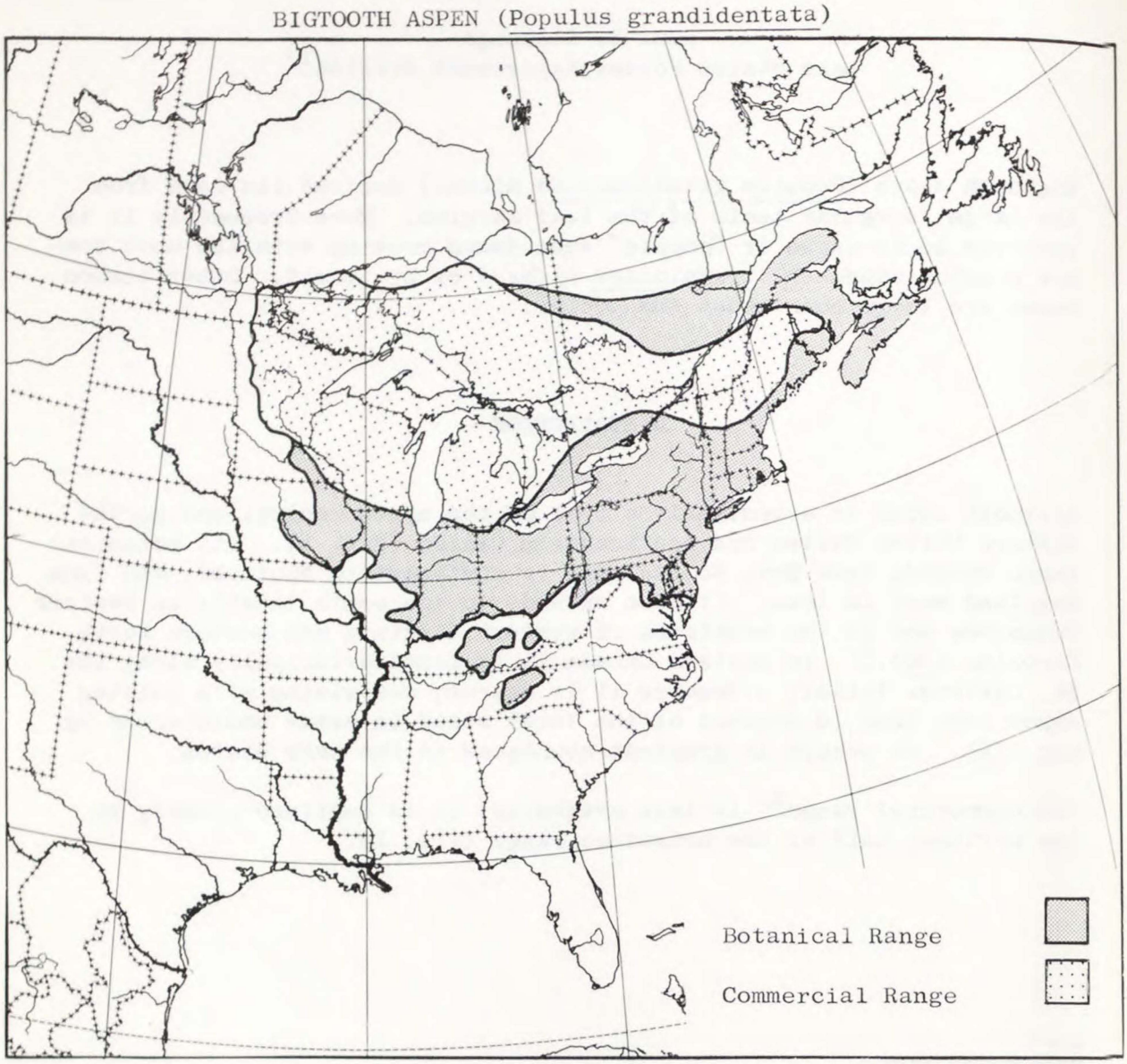

Figure 1.--Botanical and commercial range of bigtooth aspen.

HABITAT CONDITIONS

Climatic Factors

Climatic factors over the range of bigtooth aspen vary considerably when the extremes of the distribution are considered. The climate for the area as a whole would be classified as humid and microthermal, with moisture adequate at all seasons according to Thornthwaite's Climatic Provinces (29).

The mean annual precipitation varies from a low of 20 inches on the prairie border in Manitoba to a maximum of 60 inches in the Maritime provinces at the extreme east (18). From north to south it ranges from 20 to 50 inches with one-half or more falling as rain during the growing season. The mean annual snowfall exceeds 50 inches where the tree is most abundant and of best development, and exceeds 100 inches in Upper Michigan and the Northeast (45). It reaches a maximum fall of 120 inches in Nova Scotia (44).

Temperatures of -50° F. have been recorded at the northern limit of bigtooth aspen, but January temperatures average 0° in the north to 35° in the south. Summer maximums of over 100° occur over most of the range with top temperatures of 110° in the southern part. Average July temperatures range from 60° in the north to 78° in the south.

Many excellent stands of bigtooth aspen are to be found in the vicinity of Cadillac in Lower Michigan. The climate here is typical of a much larger aspen producing area. Annual precipitation averages 28 inches with 70 percent falling during the growing season. A minimum temperature of -36° has been recorded but the January temperature averages about 19°. The maximum temperature recorded is 104°; the average July temperature is 69°. The average length of the frost-free period is about 142 days (45).

Edaphic Factors

Bigtooth aspen grows on a wide variety of soils, occurring as it does in a region which, for the most part, has been subjected to glaciation. In the Lake States it is most frequent and abundant on the sandier soils which are well drained (15, 40, 41). It occurs on sands, loamy sands, and light sandy loams but is less frequent on the heavier textured loams and clays (15, 41). In northern Minnesota it is of scattered occurrence on coarse sands, gravel, and rock covered with humus (40).

Although similar in many respects to quaking aspen in its requirements, it seems to need a less fertile soil and a higher sand content for good growth in Wisconsin, good stands occurring on soils with a silt-plus-clay content of 6 to 42 percent as compared to 12 to 81 percent for quaking aspen (41). Bigtooth aspen requires the better aeration of well drained and lighter textured soils. Water tables closer to the surface than 18 inches interfere with aeration and are conducive to windthrow of the trees. In an aspen association of northern Lower Michigan, bigtooth aspen comprised 50 percent of the trees on sandy uplands and 5 percent on sandy lowlands (15). On the same areas quaking aspen accounted for 10 percent of the trees on the sandy uplands, and 60 percent on the sandy lowlands. Graham and Harrison (17) report that bigtooth aspen grows best on well drained uplands where there is an abundance of moisture within 5 feet of the surface.

Recommendations for growing bigtooth aspen in Wisconsin suggest the following site requirements: (1) a minimum depth to water table of 2 feet; (2) a minimum silt-plus-clay content of 15 percent; (3) a pH range of 4.8 to 6.0; and (4) a minimum organic matter content of 2.5 percent in the top 7-inch layer of soil (49).

Physiographic Factors

For the most part the natural range of bigtooth aspen is in a region of low relief with elevations of 500 to 2,000 feet above sea level (4). Its altitudinal range is similar to that of quaking aspen in Maine, where it can be found at sea level but grows better between altitudes of 700 and 2,000 feet, and in southeastern Kentucky, where it occurs at elevations of 1,000 to 2,000 feet (47). It occurs in the upper part of the Piedmont plateau in North Carolina at elevations of over 3,000 feet (31).

Although bigtooth aspen is essentially a tree of the uplands, it is found occasionally in lowland situations and may reach its best development on the flood plains of streams. It will seed in on cutover land of the black spruce type in the Lake States along with balsam poplar (Populus balsamifera) and quaking aspen (48). It is found on wet lowlands in northern Lower Michigan (15) and along streams and lakes in northern Indiana (13). It grows best in Iowa on lower slopes with northeast aspects or on high terraces, but occurs also on poorly drained sites along the margins of lakes and streams.[4/]

4/ Correspondence with A. L. McComb, Iowa State College, Ames, Iowa, dated Dec. 19, 1956, on file at Lake States Forest Experiment Station.

Biotic Factors

The aspens were minor but widely distributed species in the original pine, hardwood, and spruce-fir forests of the Lake States (24), presumably occupying woodland borders and accidental openings in the forest (10). They are of rare occurrence in the virgin forests of southeastern Canada (18), constituting less than 10 percent of the total stand.

Tree associates of bigtooth aspen vary over its range but depend primarily on the composition of the forest displaced by the aspen, and the degree of deterioration of the site. The species is represented in seven cover types in eastern North America (38). It occurs as a pure aspen type either singly or in various combinations with quaking aspen and balsam poplar. It is a major component of the jack pine, red pine, pin cherry, paper birch, white oak-red oak-white ash types, and a minor component of the white oak-black oak-red oak type.

The most common tree associates on nearly all site conditions and over a large part of the range are quaking aspen, gray and paper birches (Betula populifolia and B. papyrifera), and red maple (Acer rubrum).

The presence of bigtooth aspen and its associates on severely burned sand plains in northern Michigan was noted at an early date (39). Associates included quaking aspen, jack pine (Pinus banksiana), white oak (Quercus alba), black oak (Q. velutina), red oak (Q. rubra), and relict red and white pines (P. resinosa and P. strobus).

Other associates on these high sandy plains and on dry, sandy, gravelly morainal hills are northern pin oak (Q. ellipsoidalis), pin cherry (Prunus pensylvanica), black cherry (P. serotina), and sassafras (Sassafras albidum). Common shrub associates are common chokecherry (Prunus virginiana), downy serviceberry (Amelanchier arborea), sweetfern (Comptonia peregrina), and prairie willow (Salix humilis) (23). Common ground cover plants are blueberries (Vaccinium spp.), checkerberry wintergreen (Gaultheria procumbens), dwarf bushhoneysuckle (Diervilla lonicera), Allegany blackberry (Rubus allegheniensis), and smooth sumac (Rhus glabra) (15). Eastern bracken fern (Pteridium latiusculum) is extremely common. The height of full grown bracken has been suggested as an indicator of aspen site potential; the taller the fern the better the site (41).

The most common associates of bigtooth aspen in Iowa are red oak, northern pin oak, white oak, American basswood (Tilia americana), sugar maple (Acer saccharum), and American elm (Ulmus americana).4/

4/ Correspondence with A. L. McComb, Iowa State College, Ames, Iowa, dated Dec. 19, 1956, on file at Lake States Forest Experiment Station.

LIFE HISTORY

Seeding Habits

Flowering and Fruiting

The flowers of bigtooth aspen are borne in aments or catkins, with the male and female flowers being produced on different plants (33). The flowers appear before the leaves early in the growing season and the fruit ripens before the leaves are fully expanded. Observations in northern Minnesota over a 5-year period showed that initial bud swell occurred from April 24 to May 11; initial leafing, from May 19 to June 8; initial flower production, from April 23 to May 15; initial pollen production, from May 5 to May 18; and seed fall commenced between June 10 to June 17.[5/]

It has been observed in Lower Michigan that the seed is disseminated from late May until the second week in June.[6/]

In the southern parts of the botanical range average dates are as follows: leafing, April 10; flowering, March 25; seed ripening and dispersal, May 1; and leaf fall, September 15 (25).

Seed Production

Seeds are produced by vigorous trees as young as 20 years, and seed production continues throughout the life of the tree. Good crops occur every 4 to 5 years, with light seed crops during most of the intervening years (46).

A great abundance of seed is produced even though only a portion of the female trees set seed each year. The seeds are enclosed in tufts of long silky hairs or "cotton." Cleaned seeds are extremely small, numbering over 3 million to the pound (46).

5/ Unpublished data, Lake States Forest Experiment Station.

6/ Graham, S. A., et al. 1954. A study of the aspens in the Lower Peninsula of Michigan. Phoenix Proj. No. 29, 127 pp., typescript, illus. (Unpublished progress report.)

Seed Dissemination

The seeds are disseminated principally by wind and water a few days after ripening. They are transported long distances because of their light weight. This facility of dispersion helps to explain the extensive range of the species and the frequent occurrence of scattered individual trees in other forest types (24). It has been observed that the colonization of aspen on areas of burned over virgin and second-growth forest and on abandoned farmland is usually initiated by seedlings, with subsequent rapid multiplication by vegetative means (15, 40).

Vegetative Reproduction

Reproduction of bigtooth aspen is principally by root suckering despite its seemingly large potential for regeneration by seed. Seedlings as young as 2 years have been observed to produce suckers,[7/] and this suckering ability remains sufficiently unimpaired at the maximum ages reached by aspen to ensure well-stocked stands (47).[7/] The root system of aspen is shallow and wide spreading, with most of the laterals confined to the upper 6 to 12 inches of soil (12). Dormant buds present in large numbers on these horizontal roots are activated by the strong light and higher temperatures following the removal of the mother stand (50). Root suckers have been known to spring up over a radius of 30 or more feet following the removal of an aspen tree.[8/] Both sexes produce root suckers (50), making possible the existence of clones or groups in which all of the trees are either male or female.

A few suckers develop each year under undisturbed stands of aspen, but these die within a few years unless released from competition. Maximum suckering usually follows clear cutting, and in clear-cut stands the number of suckers may reach 15,000 to as high as 45,000 per acre 1 year after cutting.[9/] On burned over areas with scattered seedlings, repeated burning at not too frequent intervals will induce the suckering

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7/ Larsen, Harry S. 1953. North American aspen, its growth and management. Mich. State Univ. unpublished Master's thesis, 122 pp. Typescript.

8/ Sandberg, Dixon. 1951. The regeneration of quaking aspen by root suckering. Unpublished Master's thesis, Univ. Minn. School of Forestry, 172 pp., illus. Typescript.

9/ Correspondence with S. A. Graham, School of Natural Resources, Univ. Mich., dated July 1956, on file at Lake States Forest Experiment Station.

necessary to produce well stocked stands (15). Partial cutting produces fewer suckers, and even a light residual stand of aspen or associated species will greatly inhibit suckering.

Sprouts from young stumps following cutting or fire have been noted in Lower Michigan. From a single stump as many as 20 sprouts may arise, normally reaching heights of 3 to 6 feet the first year but occasionally up to 12 feet (15). In the course of 3 to 4 years most of the sprouts die, leaving 1 or 2 to develop. It is not known how long these persist but the parent stumps disintegrate rapidly. Sprouts bear enormous leaves.

Both bigtooth and quaking aspen have been reproduced by treating dormant cuttings with indolebutyric acid. About 65 percent of the treated cuttings will root, compared to 5 to 10 percent of the untreated. Maximum rooting is secured when dormant cuttings are taken just before the buds burst in the spring (37).

Seedling and Sucker Development

Establishment

Ripe fertile seed of bigtooth aspen, despite its small size, has an extremely high germination capacity. An average of 99 percent viable seeds has been reported in a series of 4 tests (46). While it is possible to store aspen seed successfully (22, 46), the life of the seed under natural conditions is not more than 2 or 3 weeks (24). Natural germination takes place within a day or two after seed dispersal, providing the ground is moist. It will proceed under a varied range of environmental conditions--at temperatures of 32° to 95° F. if moist, when completely submerged in water, and with or without light (14).

Bare soil is needed for seedling establishment since the young seedling has no ability to penetrate dry or deep leaf litter (8). Newly germinated seedlings are very susceptible to damage by fungi, insects, heat, and drought, and few survive. Older plants beyond the succulent stage are killed when overtopped by brush or weeds during the first year.

Suckers are harder to kill than seedlings; still their numbers are greatly reduced by competition with other suckers. Other losses result from insect and fungus attack and severe browsing by the white-tailed deer (Odocoileus virginianus).[10/] Suckers are less apt than

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10/ Graham, et al; see footnote 6 on page 6.

seedlings to be frost killed because of their later start in the spring and strong supporting root system.

Early Growth

In the absence of competing vegetation, seedlings attain heights of 12 inches or more and taproots 8 to 10 inches long the first year (36). Wide-spreading lateral roots, often two or three times the length of the stem, are formed during the second and third years. In Lower Michigan, seedlings were reported to reach heights of 6 inches during the first season and 3 to 4 feet by the end of the third year.[10/]

The growth of root suckers is more rapid than that of the seedlings due to the large parent root system. Heights of 3 to 4 feet are made from June to fall of the first year (50). Bigtooth aspen suckers usually outgrow those of associated quaking aspen, but either species may attain heights of 4 to 8 feet during the first season.[10/]

Sapling Stage to Maturity

Growth and Yield

Bigtooth aspen is a medium-sized tree, usually not more than 30 to 40 feet tall. Fairly frequently, however, trees may reach 60 to 70 feet. Recently some individuals have been observed in Michigan up to 100 feet tall (one reaching 110 feet at 60 years is shown in fig. 2) with diameters of 12 to 14 inches at 35 to 40 years of age.[11/] An occasional tree has been found with a diameter approaching 24 inches (33).

Height growth is rapid until about age 40 when it begins to slow down; height gains are negligible after 50 to 55 years. On poor, dry sites growth is slow and the trees are stubby.

Bigtooth aspen is short-lived, particularly on the poorer sites where it deteriorates rapidly after 40 to 45 years (32). On the better sites it may live to 60 or 70 years.

10/ Graham, et al; see footnote 6 on page 6.
11/ Graham; see footnote 9 on page 7.

Figure 2.--Exceptionally fine bigtooth aspens growing on rich bottomland soil in Lower Michigan. The tree being measured is 60 years old, 110 feet tall, and 19.6 inches in diameter. (Photo courtesy of Manistee News-Advocate.)

On these better sites, well-stocked stands can be expected to reach gross volumes of 30 cords per acre at age 50 years.[12/] The poorer sites are almost worthless for sawlog production and may have only 10 to 15 cords per acre at age 50 years.

Reaction to Competition

Bigtooth aspen is one of the most intolerant of deciduous forest trees throughout its range (47). This is true from the seedling or sucker stage to old age, eliminating any chance of the species to reproduce under its own shade.[13/] A recently developed numerical rating of tolerance places the aspens at 0.7, the least tolerant species, as compared to 10.0 for eastern hemlock (Tsuga canadensis), the most tolerant species (16). For this reason aspen can be maintained as a pure type only by protecting it against competition from its more tolerant associates. On good sites bigtooth aspen grows sufficiently faster than

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12/ Unpublished data, Lake States Forest Experiment Station.
13/ Larsen; see footnote 7 on page 7.

its common associates to allow it to maintain its dominant position but it still cannot reproduce under shade and usually is succeeded by more tolerant species (8).

It has been suggested that since the crown form of bigtooth aspen is broader than that of quaking aspen it cannot grow at the closer spacing tolerated by the latter species (15). Thick young aspen stands soon differentiate into crown classes, with the more vigorous individuals becoming dominant and the stands thinning rapidly. For optimum development, the upper half of the crown must have full sunlight. Overtopped trees soon become stunted, poorly formed, and defective.

Place in Succession

Bigtooth aspen is a pioneer species well suited by its reproductive capacity to move into and occupy open areas but, because of its extreme intolerance, is less suited to maintaining itself as a permanent type.

Its adaptability to varied soil and moisture conditions was proved by its successful invasion and occupation of large areas after the removal of the original hardwood, pine, and spruce-fir forests and the hot continued fires which inevitably completed the devastation.

The great reduction in forest fires and the improvement of the site by the initial crop of aspen has speeded up the successional changes of the pioneer aspen type. A recent study of the rate of conversion in Minnesota, Wisconsin, and Upper Michigan (21) indicates the following trends: The northern hardwoods and balsam fir have been more successful in displacing aspen than have the pine, and the conversion will be more complete on the better soils that they occupy than on the poorer soils characterized by oak and pine.

Bigtooth aspen moves into abandoned farmlands and now occurs as an old-field type in south central and western New York.[14/] In the western part of its range in Minnesota, its seedlings seldom invade well sodded prairie and grow poorly among shrubs that cast much shade (40).

14/ Correspondence with E. W. Littlefield, New York State Conservation Department, dated Dec. 11, 1956, on file at Lake States Forest Experiment Station.

Limiting Factors

Bigtooth aspen has many natural enemies. Fires kill the thin-barked trees, reduce the growth, and open the trunks to disease (41).

Severe weather may cause considerable damage. Breakage of the tops in sound--and particularly in cankered and borer-infested--trees is prevalent during severe wind storms. Windthrow is common due to the shallow rooting habit of the tree. Aspen is one of the most susceptible of trees to glaze injury (2). Sunscalding of the boles after heavy thinning has been reported (3).

Perhaps the most important among the insects which attack bigtooth aspen is the forest tent caterpillar (Malacosoma disstria). This insect occurs over most of the range of the species and is probably the most widespread defoliator of deciduous trees in the eastern United States (9). Bigtooth aspen has been known to suffer heavy defoliation, particularly when growing in pure or nearly pure stands.[15/] However, the species is thought to be less subject to defoliation than is quaking aspen because of its delayed leafing out. Complete foliation is attained 10 to 14 days later than in quaking aspen in Minnesota (30) and in Michigan (16). The caterpillars hatch before foliage development; therefore the insect seldom if ever becomes very abundant in pure stands of bigtooth aspen.[15/]

Other defoliators which attack bigtooth aspen include the large aspen tortrix (Archips conflictana), the satin moth (Stilpnotia salicis), and the gypsy moth (Porthetria dispar). These insects are common in the Northeast (9).

Another major pest attacking aspen is the poplar borer (Saperda calcarata). This insect attacks trees of all ages and vigor classes. The large roundheaded borers mine the stems, causing breakage and degrade. The poplar-gall saperda (S. concolor) feeds in the branches of young trees, causing breakage and death of the branches (9).

Bigtooth aspen is subject to a large number of diseases; one investigator has listed 48 (35). The most serious are those causing rot in the boles--the greatest single cause of cull in aspen. Three fungi--Fomes igniarius, F. applanatus, and Armillaria mellea--cause most of the decay in aspen (5). The white heartrot caused by the false tinder fungus (Fomes igniarius) is most important.

15/ Graham; see footnote 9 on page 7.

Hypoxylon canker (Hypoxylon pruinatum) is widely distributed in the Northeastern States and the Lake States and causes heavy losses in the younger aspen stands. Bigtooth aspen is less frequently attacked than quaking aspen (5). If the cankers are located below the live crown the trees may be killed directly by girdling or the trunk may break at the damaged portion. Frequently the break of the trunk is not complete, leaving the dead crown hanging top down. The incidence of the disease is not correlated with site quality or tree vigor (1), but the effects of the canker are more noticeable on poor sites because the slower growing trees are exposed to infection longer before reaching merchantable size.

Two other cankers (Valsa sordida and V. nivea) are particularly common on bigtooth aspen in the Northeast, causing the death of small trees and branches by girdling (2, 34). The two common aspens have the greatest amount of fatal infection in stands up to 8 or 10 years old and in the weaker trees; hence these diseases may be beneficial in thinning over-dense stands (5). Commonly attacking bigtooth in New England is another canker, Nectria spp. (2).

Ink spot of aspen (Sclerotinia bifrons) is a foliage disease that is rare on bigtooth aspen but very common on quaking aspen (5).

Among the species of wildlife that feed on aspen or cause damage to aspen stands indirectly are the whitetailed deer and the snowshoe hare (Lepus americanus). Both are instrumental in thinning down reproduction of bigtooth aspen (42). Beaver (Castor canadensis), through their dam building activities, often kill many aspens by flooding. Beaver consider aspens a preferred food; they fell trees of all sizes and eat the bark and twigs (6). In Michigan, trees have been cut to a distance of 500 feet from the shores of a lake (6). Porcupines (Erethizon dorsatum) consume many small branches and feed on the outer bark of larger stems. The buds are eaten by ruffed grouse (Bonasa umbellus) and the sharp-tailed grouse (Pedioecetes phasianellus).

SPECIAL FEATURES

The outstanding special feature of bigtooth aspen is its ability to increase its numbers by root sprouts or suckers following fire or clear cutting. This reproductive capacity along with its long-distance seeding is responsible for its present prominence as a commercial species and will help ensure its permanence.

The wood is light brown with almost white sapwood, light in weight, and soft, with a fine uniform texture (7). Its principal uses have been for pulpwood, lumber, excelsior, and matches (26).

The unfolding leaves of bigtooth aspen are densely pubescent but later become glabrous. This character sets them apart from quaking aspen, which has glabrous leaves from the start. The leaves of bigtooth have flattened stems and also tremble or quake like those of quaking aspen.

RACES, HYBRIDS, AND OTHER GENETIC FEATURES

Natural hybrids of bigtooth and quaking aspen have been reported from Canada and from central and eastern Massachusetts, and probably occur throughout the common range of the aspens (30). Hybrids of the European Populus alba and bigtooth aspen are abundant where the European white poplar has been planted (20). Natural hybrids of the two species have been found in two localities in Iowa (28). At age 24 years these trees exhibit the superior form of the bigtooth and the rapid growth rate of the European white poplar, having a volume of 32 cords per acre. One stand represents a clone that produces wood with an attractive figure suitable for veneer stock (27).

Artificial crosses have been made with a number of other Populus species. Some of the more promising of these now under observation but still too young to evaluate as to their forest quality are (20):

Populus alba x grandidentata
P. tomentosa x grandidentata x grandidentata
P. canescens x grandidentata

Populus canescens is the hybrid P. alba x tremula. The crosses P. canescens x grandidentata and P. tomentosa x grandidentata have grown fast and show a degree of disease resistance (19).

The cross Populus grandidentata x tremuloides is easily made, and the F_1 hybrids are intermediate in most morphological characteristics (30). Hybrids of Populus grandidentata x deltoides have been produced but are much less vigorous than hybrids from other crosses within the same genus (43).

Vegetative cells of normal wild bigtooth aspens have 19 pairs (38) of chromosomes (11).

LITERATURE CITED

1. Anderson, Ralph L.
   1953. Hypoxylon canker of aspen in the Lake States. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 400, 1 p. (Processed.)

2. Baxter, Dow V.
   1943. Pathology in forest practice. 618 pp., illus. New York.

3. Bickerstaff, A.
   1946. The effect of thinning upon the growth and yield of aspen stands. Proj. P-19, Dominion Forest Serv. Silvic. Res. Note 80, 25 pp. (Processed.)

4. Bowman, Isaiah.
   1911. Forest physiography. 759 pp., illus. New York.

5. Boyce, John Shaw.
   1948. Forest pathology. Ed. 2, 550 pp., illus. New York, Toronto, and London.

6. Bradt, G. W.
   1947. Michigan beaver management. Mich. Dept. Conserv., 56 pp., illus.

7. Canada Forestry Branch.
   1956. Native trees of Canada. Ed. 5, Dept. North. Aff. and Natl. Resources, Forestry Branch Bul. 61, 293 pp., illus.

8. Cheyney, Edward G.
   1942. American silvics and silviculture. 472 pp., illus. Minneapolis.

9. Craighead, F. C.
   1950. Insect enemies of eastern forests. U. S. Dept. Agr. Misc. Pub. 657, 679 pp., illus.

10. Cunningham, R. N.
    1950. Forest resources of the Lake States region. U. S. Dept. Agr. Forest Resource Rpt. 1, 57 pp., illus.

11. Darlington, C. D., and Wylie, A. P.
    1956. Chromosome atlas of flowering plants. 519 pp., illus. New York.

12. Day, M. W.
    1944. The root system of the aspen. Amer. Midland Nat. 32: 502-509, illus.

13. Deam, Charles C., and Shaw, T. E.
    1953. Trees of Indiana. Ind. Dept. Conserv., Pub. 13a, 329 pp., illus. Indianapolis.

14. Faust, Mildred E.
    1936. Germination of Populus grandidentata and P. tremuloides with particular reference to oxygen consumption. Bot. Gaz. 97: 808-821, illus.

15. Gates, Frank C.
    1930. Aspen association in northern Lower Michigan. Bot. Gaz. 90: 233-259, illus.

16. Graham, Samuel A.
    1954. Scoring tolerance of forest trees. Univ. Mich., School Nat. Resources, Mich. Forestry 4, 2 pp. (Processed.)

17. _____ and Harrison, Robert P.
    1955. Site identification for bigtooth aspen sucker stands. Univ. Mich. Forestry Note 10, 4 pp., illus. (Processed.)

18. Halliday, W. E. D., and Brown, A. W. A.
    1943. The distribution of some important forest trees in Canada. Ecol. 24: 353-373, illus.

19. Heimburger, C. C.
    1940. Report on poplar hybridization. II. 1937 and 1938, Forestry Chron. 16: 149-160.

20. _____.
    1953. The present status of forest tree breeding in Canada. Lake States Forest Genetics Conf. Proc. Mar. 31-Apr. 1, 1953: 33-41. U. S. Forest Serv., Lake States Forest Expt. Sta. Misc. Rpt. 22. (Processed.)

21. Heinselman, M. L.
    1954. The extent of natural conversion to other species in the Lake States aspen-birch type. Jour. Forestry 52: 737-738.

22. Johnson, L. P. V.
    1946. The effect of humidity on the longevity of Populus and Ulmus seeds in storage. Canad. Jour. Res. (Sec. C)24: 298-302.

23. Kittredge, J., Jr., and Chittenden, A. K.
    1929. Oak forests of northern Michigan. Mich. Agr. Expt. Sta. Spec. Bul. 190, 47 pp., illus.

24. _____, and Gevorkiantz, S. R.
    1929. Forest possibilities of aspen lands in the Lake States. Univ. Minn. Agr. Expt. Sta. Tech. Bul. 60, 84 pp., illus.

25. Lamb, George N.
    1915. A calendar of the leafing, flowering, and seeding of the common trees of the eastern United States. U. S. Monthly Weather Rev., Sup. 2, pp. 3-19, illus.

26. Little, Elbert L., Jr.
    1953. Check list of native and naturalized trees of the United States (including Alaska). U. S. Dept. Agr. Handb. 41, 472 pp.

27. _____, Brinkman, Kenneth A., and McComb, A. L.
    1957. Two natural Iowa hybrid poplars. Forest Sci. 3: 253-262, illus.

28. McComb, A. L., and Hansen, Norman J.
    1954. A naturally occurring aspen-poplar hybrid. Jour. Forestry 52: 528-529.

29. Marbut, C. F.
    1935. Soils of the United States. In Atlas of Amer. Agr., Part III, U. S. Dept. Agr., 98 pp., illus.

30. Pauley, Scott S.
    1956. Natural hybridization of the aspens. Univ. Minn. Forestry Note 47, 2 pp., illus. (Processed.)

31. Pinchot, Gifford, and Ashe, W. W.
    1897. Timber trees and forests of North Carolina. N. C. Geol. Surv. Bul. No. 6, 227 pp., illus.

32. Robinove, J. J., and Horton, C. W.
    1929. The growth rate of aspens in the region around Douglas Lake, Michigan. Amer. Jour. Bot. 16: 169-172.

33. Sargent, Charles S.
    1933. Manual of trees of North America (exclusive of Mexico). Ed. 2, 910 pp., illus. Boston.

34. Schreiner, Ernst J.
1931. The role of disease in the growing of poplar. Jour. Forestry 29: 79-82.

35. Seymour, A. B.
1929. Host index of the fungi of North America. 732 pp., Cambridge, Mass.

36. Shirley, H. L.
1941. Restoring conifers to aspen lands in the Lake States. U. S. Dept. Agr. Tech. Bul. 763, 36 pp., illus.

37. Snow, Albert G., Jr.
1938. Use of indolebutyric acid to stimulate the rooting of dormant aspen cuttings. Jour. Forestry 36: 582-587, illus.

38. Society of American Foresters.
1954. Forest cover types of North America (exclusive of Mexico). Rpt. of Com. on Forest Types, 67 pp., illus. Washington, D. C.

39. Spaulding, V. M.
1883. The plains of Michigan. Amer. Nat. 17: 249-259.

40. Stallard, Harvey.
1929. Secondary succession in the climax forest formations of northern Minnesota. Ecol. 10: 476-547.

41. Stoeckeler, J. H.
1948. The growth of quaking aspen as affected by soil properties and fire. Jour. Forestry 46: 727-737.

42. _____, Strothmann, R. O., and Krefting, L. W.
1957. Effect of deer browsing on reproduction in the northern hardwood-hemlock type in northeastern Wisconsin. Jour. Wildlife Mangt. 21(1): 75-80.

43. Stout, A. B., and Schreiner, Ernst J.
1934. Hybrids between the necklace cottonwood and the large-leaved aspen. Jour. N. Y. Bot. Garden 35: 140-143.

44. Thomas, Morley K.
1953. Climatological atlas of Canada. Canada Dept. Transport., Met. Div., and Natl. Res. Council, Div. Bldg. Res., 253 pp., illus. Ottawa.

45. U. S. Department of Agriculture.
1941. Climate and Man. U. S. Dept. Agr. Yearbook. 1,248 pp., illus.

46. U. S. Forest Service.
1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

47. Weigle, W. G., and Frothingham, E. H.
1911. The aspens: their growth and management. U. S. Dept. Agr. Forest Serv. Bul. 93, 35 pp.

48. Westveld, R. H.
1949. Applied silviculture in the United States. Ed. 2, 590 pp., illus. New York.

49. Wilde, S. A., Wilson, F. G., and White, D. P.
1949. Soils of Wisconsin in relation to silviculture. Wis. Conserv. Dept. Pub. 525-49, 171 pp., illus.

50. Zehngraff, Paul.
1949. Aspen as a forest crop in the Lake States. Jour. Forestry 47: 555-565.

SILVICAL REPORTS PUBLISHED OR IN PREPARATION

This is the twelfth of the silvical reports being prepared by the Lake States Forest Experiment Station. Already published are:

Station Paper 44 - Red pine
Station Paper 45 - Black spruce
Station Paper 47 - Rock elm
Station Paper 49 - Quaking aspen
Station Paper 50 - Sugar maple
Station Paper 52 - Tamarack
Station Paper 54 - American elm
Station Paper 55 - White spruce
Station Paper 59 - Slippery elm
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Station Paper 62 - American basswood

Ensuing reports will cover the following species:

Black maple
Balsam poplar
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Station Paper 51, 58 pp., illus. 1957.

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Station Paper 53, 47 pp., illus. 1957.

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Station Paper 56, 20 pp., illus. 1957.

Managing Red Pine for Poles in Lower Michigan.
Paul C. Guilkey.
Station Paper 57, 21 pp., illus. 1958.

Proceedings, Third Lake States Forest Tree Improvement Conference, Sept. 17, 18, 1957.
Lake States Forest Experiment Station.
Station Paper 58, 87 pp., illus. 1958.

The Forest Insect and Disease Situation, Lake States, 1957.
Donald C. Schmiege and R. L. Anderson.
Station Paper 60, 22 pp., illus. 1958.